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DATASETS OF ODONTOCETE SOUNDS ANNOTATED FOR DEVELOPING AUTOMATIC DETECTION METHODS, FY09-10

by

David K. Mellinger

September 2012

Prepared for: Chief of Naval Operations
Energy and Environmental Readiness Division,
Washington, D.C.

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The report entitled *"Datasets of Odontocete Sounds Annotated for Developing Automatic Detection Methods, FY09-10"* was prepared for and funded by the Chief of Naval Operations [CNO(N45)], Washington, D.C. The report was prepared by Oregon State University and supported under NPS Grant N00244-09-1-0079.

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REPORT DOCUMENTATION PAGE

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1. REPORT DATE (DD-MM-YYYY) 09-26-2012	2. REPORT TYPE Technical Report	3. DATES COVERED (From-To) 1 Oct.2009 – 30 Sept. 2010

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER N00244-09-1-0079
Datasets of Odontocete Sounds Annotated for Developing Automatic Detection Methods, FY09-10	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
David K. Mellinger	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES) Cooperative Institute for Marine Resources Studies Oregon State University, Newport, Oregon 97365	8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Sponsoring Agency: CNO (N45), Washington, D.C. Monitoring Agency: Department of Oceanography, Naval Postgraduate School, 833 Dyer Rd. Monterey, CA 93943-5122	10. SPONSOR/MONITOR'S ACRONYM(S) Sponsoring Agency: CNO Monitoring Agency: NPS
	11. SPONSOR/MONITOR'S REPORT NUMBER(S) NPS-OC-12-004CR

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
The views expressed in this report are those of the authors and do not reflect the official policy or position of the Department of Defense or the US Government.

14. ABSTRACT
Detection, classification, and localization (DCL) research on marine mammal vocalizations has been in development for decades, and methods for marine mammal population density estimation using acoustic data have been in development since at least 2007. These efforts have been supported by MobySound, an archive of cetacean sounds used for studying call detection and localization that are annotated to facilitate research in DCL. This project was aimed to begin development of high-performing automatic detection methods for the sounds of beaked whales and other odontocetes. Specifically, this report [1] details the newly collected odontocete recordings that have been added to the MobySound archive; [2] documents continuing development of methods for detection and classification, including improvements to the Energy Ratio Mapping Algorithm (ERMA) method for use on gliders and its extension to new species and populations; [3] reports on development of a new method for estimating the population density of baleen whales using the summed energy in a frequency band in which they vocalize; and [4] also reports on the successful production of datasets focused on odontocete whistles and clicks and baleen whale calls for the Fifth Workshop on Detection, Classification, Localization, and Density Estimation of Marine Mammals using Passive Acoustics.

15. SUBJECT TERMS
Marine mammal vocalizations, passive acoustic monitoring, Detection/Classification/Localization (DCL), MobySound archive, odontocetes, mysticetes, ERMA.

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Tarry Rago
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified	UU	34	19b. TELEPHONE NUMBER (include area code) 831-656-3349

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Contents

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Datasets of odontocete sounds annotated for developing automatic detection methods, FY09-10

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Project Overview

The Navy is required by environmental laws, including the Endangered Species Act, the Marine Mammal Protection Act, and the National Environmental Policy Act, to conduct its research and operations with minimal impacts on marine mammals, and to mitigate any adverse impacts caused by those transactions. In compliance, the Navy has been compelled to monitor the occurrence and behavior of marine mammals before, during and after research and operational activities. Acoustic methods have become a primary tool used for this task; they are now routinely and widely used in marine mammal research, monitoring, and mitigation.

Item 9 of the document "U.S. Navy Living Marine Resource and Sound Research Requirements" calls for the Navy to "Determine what real time observation, detection, and classification measures are required to develop effective monitoring and mitigation procedures," with special emphasis on sub-part (a), "Means to detect whether priority species have been affected by Navy sounds," and (c), "Means to test the effectiveness of mitigation measures." The advancement of methods and software for *d*etection, *c*lassification, and *l*ocalization (DCL) of marine mammal sounds has been one area of research which supports the Navy in fulfilling this requirement.

DCL research on marine mammal vocalizations has been in development for decades, and methods for marine mammal population density estimation using acoustic data have been in development since at least 2007. These efforts have been supported by MobySound, an archive of cetacean sounds used for studying call detection and localization that are annotated to facilitate research in DCL.

Since the inception of MobySound in the mid 1990s, it has expanded from being an archive of baleen whale (mysticete) sounds to include annotated recordings of toothed whale (odontocete) species. This expansion converged with the advent of the biennial Workshops on the Detection, Classification, and Localization (DCL) of Marine Mammals using Passive Acoustics. There have now been five of these workshops, and the data sets for all of them are part of MobySound. With the additions to MobySound in recent years, there are now 22 datasets covering 18 species in the archive.

Some of the better detection and classification methods that have been developed by using data sets in MobySound have been on endangered species, including sperm [1-4], blue [5-6], and right [7-19] whales, and high-priority species, including beaked whales [20-25]. These projects have used click characteristics as the feature for automatic detection, classification and identification; a recent application has been development of a low-power detection method known as ERMA [21, 23, 26-28] suitable for use on ocean gliders. MobySound data are being used to develop, test, and improve ERMA.

The major aim of this project was to begin development of high-performing automatic detection methods for the sounds of beaked whales and other odontocetes. The specific aims were to collect recordings with calls; annotate these sound files to make them useful to researchers working on automatic call detection and classification; make them publicly available in an archive on the Internet; continue developing and publishing detection and classification methods and software; integrate these methods with new autonomous platforms and detection systems; develop a new method for population density estimation based on sound density and apply it to field recordings; and prepare a workshop dataset for the 2011 International Workshop on the Detection, Classification, and Localization of Marine Mammals using Passive Acoustics, which occurred August 21-25, 2011, in Oregon.

In more detail, project tasks were as follows:

(1) **Annotate recordings** of odontocete sounds (whistles, clicks) and add these to MobySound.
(2) **Detection/classification:** Continue developing detection and classification methods and software, and integrating these methods with new platforms including gliders and robotic sailboats.
(3) **Density estimation:** Apply a newly-developed method for population density estimation to field recordings.
(4) **Workshop dataset:** Produce datasets for detection, classification, and localization for the 2011 DCL conference, which my lab is organizing.

Results

The results by task are as follows:

(1) **[Annotate recordings]** We collected data sets of odontocete recordings containing whistles and clicks for addition to our archive site MobySound.org. These recordings include sounds of Baird's beaked whale (*Berardius bairdii*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), northern right whale dolphin (*Lissodelphis borealis*), long-beaked common dolphin (*Delphinus capensis*), short-beaked common dolphin (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*), bottlenose dolphin (*Tursiops truncatus*) and killer whale (*Orcinus orca*) from the U.S. West Coast; sperm whale (*Physeter macrocephalus*), pantropical spotted dolphin (*Stenella attenuata*), striped dolphin (*Stenella coeruleoalba*), short-finned pilot whale (*Globicephala macrorhynchus*), false killer whale (*Pseudorca crassidens*), melon-headed whale (*Peponocephala electra*), bottlenose dolphin (*Tursiops truncatus*), rough-toothed dolphin (*Steno bredanensis*), and spinner dolphin (*Stenella longirostris*) from the eastern tropical Pacific; killer whale (*Orcinus orca*) from the south Atlantic; and gray whales (*Eschrichtius robustus*) from the eastern Pacific (Mexico). Many of these recordings have been annotated for clicks and whistles. Recordings of Dall's porpoise (*Phocoenoides dalli*), harbor porpoise (*Phocoena phocoena*) and killer whales

(*Orcinus orca*) from the north Pacific were also collected for eventual addition to MobySound.org.

The MobySound archive has been accessed increasingly often since being moved to a new host. The website has had approximately 900 unique visitor usages in a one-year span and many thousands of accesses (hits). The front page of this website is shown in Appendix 2.

We also developed a new method for measuring signal-to-noise ratio (SNR) of whistle sounds. Existing MobySound recordings comprise baleen whale moans and odontocete clicks; the methods for measuring SNR for these are not applicable to whistles-- particularly whistles mixed with clicks, as are found in most whistle recordings. We developed a new method in MATLAB, snrWhistle.m, for measuring the SNR of whistles in the presence of clicks, and published it via the MobySound website.

(2) **[Detection/classification]** We continued to develop methods for detection and classification, including improvements to the ERMA method for use on gliders **[26-28]**, and extended it to new species and populations. The methods were employed in the glider deployments collected in the Navy's AUTEC range in the Bahamas in summer 2010 and off the Kona coast of Hawaii in late 2009. Species for which ERMA detectors have been developed now include Cuvier's beaked whales (*Ziphius cavirostris*), Blainville's beaked whales (*Mesoplodon densirostris*), and killer whales (*Orcinus orca*). ERMA, as part of its detection algorithm, incorporates information about confounding species in the geographic region where it is used; the list of regions for which this has been done now includes Washington state (Haro Strait area), Hawaii (Kona coast of the big island of Hawai'i), and the Bahamas (Andros Island area). Detection results from the Kona experiment showed that during the mission ERMA detected beaked whale vocalizations on 10 out of 85 glider dives. Manual analysis revealed that 7 of these detections were actual beaked whale encounters. During the other 3 glider dives the detection system was mistakenly triggered by delphinid vocalizations. The analyst identified a total of 109 sound files containing beaked whale clicks. The automated system correctly detected calls in 79 out of these 109 sound files (72%). Results from this development were recently published in a peer-reviewed journal **[37]**.

(3) **[Density estimation]** A new method was developed for estimating the population density of baleen whales using the summed energy in a frequency band in which they vocalize. The method was not applied to the case study of humpback whales in the Bering Sea, because that dataset turned out to have too much confounding noise; instead, the case study used was of fin whales. The method produced a number for the population density, but has not been verified yet. A separate effort is under way (the Cheap DECAF project) to estimate the density of fin whales using other methods; and when that is done, the results from that project will be compared to results from this method. The method is the subject of a forthcoming paper **[38]** defining the method and showing its results for this case study.

(4) **[Workshop dataset]** We coordinated the production of datasets focused on odontocete whistles and clicks and baleen whale calls for the Fifth Workshop on Detection, Classification, Localization, and Density Estimation of Marine Mammals using Passive Acoustics, which we hosted at Timberline Lodge, Mt. Hood, Oregon, from August 22-25, 2011. We prepared these datasets as common ground for comparing methods in collaboration with Marie Roch (Scripps Institution of Oceanography and San Diego State University) for the classification dataset and Eva-Marie Nosal (University of Hawaii) and Steve Martin (SPAWAR) for the localization dataset. This dataset was released approximately six months before the workshop on the MobySound web site and was used by conference attendees. A comparison of results of methods tested on this dataset was included.

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Appendix 1:

Status summary of recordings in or available to the archive

Species	Common Name	Region	N sounds	N files	N (s)	Source
CURRENT						
Mysticetes (baleen whales)						
Balaena mysticetus	bowhead whale	northern Alaska	589	128	3580	NOAA/CIMRS
		northeastern Alaska		45	2500	Greenridge Sciences, Inc.
		northwestern Alaska		9	18313	JASCO
Balaenoptera acutorostrata	Minke whale	north Atlantic	178	5	13185	NOAA/CIMRS
		western tropical Pacific		29		Biowaves, Inc.
Balaenoptera borealis	Sei whale	western tropical Pacific		4		Biowaves, Inc.
Balaenoptera edeni	Bryde's whale	eastern tropical Pacific	1402	12	364600	NOAA/CIMRS
		western tropical Pacific		2		Biowaves, Inc.
Balaenoptera musculus	blue whale	north Atlantic	405	9	1401	NOAA/CIMRS
Balaenoptera physalus	fin whale	north Atlantic	3066	15	75320	NOAA/CIMRS
Eschrichtius robustus	Gray whale	Baja Mexico	9697			Independent researcher
Eubalaena australis	southern right whale	South Africa	67	5	2273	Independent researcher
Eubalaena glacialis	north Atlantic right whale					NOAA/CIMRS
Eubalaena japonica	north Pacific right whale	Bering Sea	38	6	4496	NOAA/CIMRS
Megaptera novaeangliae	humpback whale	north Atlantic	2310	14	7600	NOAA/CIMRS
		western tropical Pacific		11		Biowaves, Inc.
Odontocetes (toothed whales and dolphins)						
Globicephala macrorhynchus	short-finned pilot whale	AUTEC, North Atlantic	55933	9	13500	NUWC
		north Atlantic, Canary isles		1	2000	MEER e.V.
		northwestern Pacific		2		Biowaves, Inc.
Globicephala melaena	long-finned pilot whale	Mediterranean		16		Univ. Pavia, Italy
Grampus griseus	Risso's Dolphins	SCORE, Southern Calif.		10	17100	SIO
		Mediterranean		6		Univ. Pavia, Italy
Peponocephala electra	Melon-headed whale	northwestern Pacific		1		Biowaves, Inc.
Physeter macrocephalus	sperm whale	AUTEC, North Atlantic		3	2790	NUWC
		western tropical Pacific		61		Biowaves, Inc.
		Mediterranean		6		Univ. Crete
Pseudorca crassidens	False killer whales	western tropical Pacific		10		Biowaves, Inc.
Stenella attenuata	pantropical spotted dolphin	western tropical Pacific		11		Biowaves, Inc.
Stenella coeruleoalba	Striped Dolphin	western tropical Pacific		9		Biowaves, Inc.

Species	Common name	Location				Institution
Stenella longirostris	Spinner Dolphin	western tropical Pacific		1		Biowaves, Inc.
Steno bredanensis	rough-toothed Dolphin	AUTEC, North Atlantic		2	3600	NUWC
		north Atlantic, Canary isles		1	900	MEER e.V.
		western tropical Pacific		1		Biowaves, Inc.
Stenella spp.	spotted dolphin	AUTEC, North Atlantic		1	1800	NUWC
		north Atlantic, Canary isles		1	900	MEER e.V.
Tursiops truncatus	bottlenose dolphin	north Atlantic, Canary isles		1	900	MEER e.V.
		western tropical Pacific		1		Biowaves, Inc.
Odontocetes- beaked whales						
Berardius arnuxii	Arnoux's Beaked Whale	Antarctic	3379	3	8409	Univ. New S. Wales
Berardius bairdii	Baird's Beaked Whale	north Pacific		21	7233	NMML/APL/NOAA
		Baja Mexico		60	3600	NMML/NOAA
Mesoplodon densirostris	Blainville's Beaked Whale	AUTEC, North Atlantic	3637	41	67613	AUTEC
		north Atlantic, Canary isles.	3000	1	1260	WHOI
		eastern tropical Pacific		3	19.7	NOAA
Mesoplodon spp.	Beaked whales	western tropical Pacific				Biowaves, Inc.
Ziphius cavirostris	Cuvier's Beaked Whale	Mediterranean	3137	1	1800	WHOI
		Mediterranean		10		Univ. Pavia, Italy
Pinnipeds (seals)						
Lobodon carcinophagus	crab eater seal	Antarctic	3940	714	42840	PALAOA
Hydrurga leptonyx	leopard seal	Antarctic	7249	3923	235440	PALAOA
Erignathus barbatus	bearded seal	northern Alaska		2	1000	Greenridge Sciences, Inc.

EXTANT: *Annotated and available to archive*

Species	Common name	Location				Institution
Mysticetes (Baleen whales)						
Balaenoptera acutorostrata	Minke whale	eastern tropical Pacific				Bio-Waves Inc.
Megaptera novaeangliae	humpback whale	north Atlantic				OASIS, Inc.
		eastern tropical Pacific				Bio-Waves Inc.
Odontocetes (toothed whales and dolphins)- beaked whales						
Delphinus capensis	long-beaked common dolphin	SCORE, Southern Calif.				SIO
Delphinus delphis	short-beaked common dolphin	SCORE, Southern Calif.				SIO
Orcinus orca	killer whale	Southern Puget Sound				Independent Researcher
Physeter macrocephalus	sperm whale	Mediterranean				Univ. Crete
		Gulf of Mexico				Univ. New Orleans
Pinnipeds (seals)						
Phoca vitulina	harbor seals	California coastline				NMFS/NOAA

*Abbreviations:

AUTEC	Atlantic Undersea Test and Evaluation Center	PALAOA	Perennial Acoustic Observatory in the Antarctic Ocean
CIMRS	Cooperative Institute for Marine Resources Studies	SCORE	Southern California Offshore Range
NMML	National Marine Mammal Laboratory	SIO	Scripps Institution of Oceanography
NOAA	National Oceanic and Atmospheric Administration	UW-APL	University of Washington, Applied Physics Laboratory
NUWC	Naval Undersea Warfare Center	WHOI	Woods Hole Oceanographic Institute

Appendix 2:
Home page of open access website
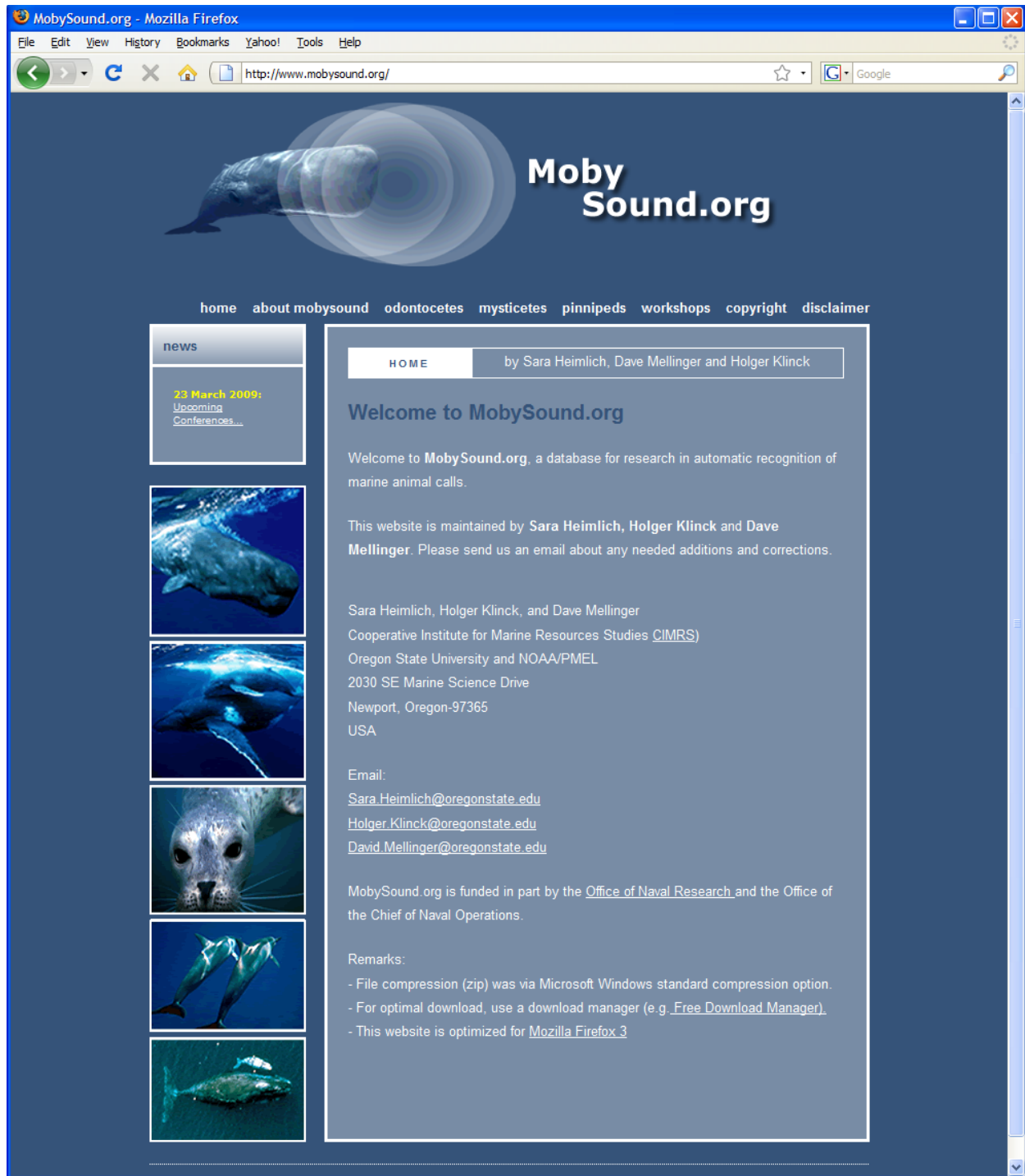
Appendix 3: Publications and Presentations

Articles in peer-reviewed journals

KLINCK, H., AND D. K. MELLINGER. **2011**. The energy ratio mapping algorithm (ERMA): a tool to improve the energy-based detection of odontocete clicks. *J. Acoust. Soc. Am.* **129(4):** 1807-1812.

KLINCK, H., D. K. MELLINGER, K. KLINCK, J. HAGER, L. KINDERMANN, AND O. BOEBEL. **2010**. Long-range underwater vocalizations of the crabeater seal (*Lobodon carcinophaga*). *J. Acoust. Soc. Am.* **128(1):** 474-479.

KÜSEL, E. T., D. K. MELLINGER, L. THOMAS, T. A. MARQUES, D. MORETTI, AND J. WARD. **2011**. Cetacean population density estimation from single fixed sensors using passive acoustics. *J. Acoust. Soc. Am.* **129(6):** 3610-3622.

MELLINGER, D. K., R. P. MORRISSEY, S. W. MARTIN, L. THOMAS, T. A. MARQUES, AND J. YOSCO. **2011**. A method for detecting whistles, moans, and other frequency contours. *J. Acoust. Soc. Am.* **129(6):** 4055-4061.

MELLINGER, D. K., S. NIEUKIRK, K. KLINCK, H. KLINCK, R. P. DZIAK, P. J. CLAPHAM, B. BRANDSDÓTTIR. **2011**. Confirmation of right whales near an historic whaling ground east of southern Greenland. *Biol. Lett.* **7(3):** 411-413. **doi:**10.1098/rsbl.2010.1191.

ROCH, M. A., H. KLINCK, S. BAUMANN-PICKERING, D. K. MELLINGER, S. QUI, M. S. SOLDEVILLA, AND J. A. HILDEBRAND. **2011**. Classification of echolocation clicks from odontocetes in the Southern California Bight. *J. Acoust. Soc. Am.* **129(1):** 467-475.

STAFFORD, K. M., S. E. MOORE, P. J. STABENO, D. V. HOLLIDAY, J. M. NAPP, AND D. K. MELLINGER. **2010**. Biophysical ocean observation in the southeastern Bering Sea. *Geophys. Res. Lett.* **37:** L02606. **doi:**10.1029/2009GL040724. 4 pp.

YACK, T. M., J. BARLOW, M. A. ROCH, H. KLINCK, S. MARTIN, D. K. MELLINGER, AND D. GILLESPIE. **2010**. Comparison of beaked whale detection algorithms. *Applied Acoust.* **71(11):** 1043-1049.

Conference papers (non-refereed)

MARQUES, T. A., S. W. MARTIN, R. P. MORRISSEY, S. JARVIS, N. DiMARZIO, D. MORETTI, AND D. K. MELLINGER. **28 Sept.-1 Oct. 2011**. Spatially explicit capture-recapture minke whale density estimation. *Proc. XIX Congresso Anual da Sociedade Portuguesa de Estatística*. Nazare, Portugal. 2 pp.

MELLINGER, D.K. **2011**. Signal processing and analysis (detection, classification and localization of marine mammal sounds). *In:* BINGHAM, G. Status and Applications of Acoustic Mitigation and Monitoring Systems for Marine Mammals: Workshop Proceedings. (**17-19Nov. 2009**. Boston, Massachusetts) *U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Gulf of Mexico OCS Region, New Orleans* **OCS Study BOEMRE 2011-002:** 35-38.

SAGEN, H., S. SANDVEN, A. BESZCZYNSKA-MOELLER, O. BOEBEL, T. F. DUDA, L. FREITAG, J. C. GASCARD, A. GAVRILOV, C. M. LEE, D. K. MELLINGER, P. MIKHALEVSKY, S. MOORE, A. K. MOROZOV, M. RIXEN, E. SKARSOULIS, K. STAFFORD, E. TVEIT, AND P. F. WORCESTER. **21-25 Sept. 2009**. Acoustic technologies for observing the interior of the Arctic Ocean. *Proc. OceanObs'09*. Venice, Italy. 5 pp.

Presentations with published abstracts

BOGUE, N. M., J. C. LUBY, W. A. JUMP, J. M. PYLE, G. B. SHILLING, T. LITCHENDORF, A. S. WOOD, D. K. MELLINGER, H. KLINCK. **7-10 Dec. 2009**. Passive acoustic monitoring using Seaglider: initial deployments. *Book of abstracts*, pp52-53. *ONR Marine Mammal Program Review*. Alexandria, Virginia.

CONSTANTINOU, N., H. KLINCK, T. L. ROGERS, S. LAFFAN, D. K. MELLINGER, R. P. DZIAK, AND M. PARK. **23-27 Aug. 2010**. Can passive acoustics identify the driving factors behind changes in marine mammal abundance and distribution? *Proc. Intl. Congress on Acoustics*. Sydney, Australia.

COWLES, T. J., K. BENOIT-BIRD, AND D. K. MELLINGER. **7-10 Dec. 2009**. Factors influencing the acoustic behavior and nearshore residence of the gray whale (*Eschrichtius robustus*) along their migration route. *Book of abstracts*, pp.104-105, *ONR Marine Mammal Program Review*. Alexandria, Virginia.

CRANCE, J., C. BERCHOK, P. CLAPHAM, M. LAMMERS, W. W. L. AU, D. K. MELLINGER, AND S. NIEUKIRK. **2010**. Right whale distribution in the Bering Sea revisited: A fresh look. *J. Acoust. Soc. Am.* **127(3):** 1758(A).

DELARUE, J., D. K. MELLINGER, K. M. STAFFORD, AND C. L. BERCHOK. **2010**. Where do the Chukchi Sea fin whales come from? Looking for answers in the structure of songs recorded in the Bering Sea and Western North Pacific. *J. Acoust. Soc. Am.* **127(3):** 1758(A).

HAXEL, J. H., R. P. DZIAK, M. PARK, D. R. BOHNENSTIEHL, H. MATSUMOTO, W. LEE, M. J. FOWLER, T. A. LAU, D. K. MELLINGER, AND H. KLINCK. **22-26 Feb. 2010**. Regional comparisons of deep-ocean sound in the Southern Ocean. *Abstract IT35M-08*, p.78. *Ocean Sciences Meeting.* Portland, Oregon.

HEIMLICH, S. L., D. K. MELLINGER, H. KLINCK, K. STAFFORD, S. E. MOORE, C. BERCHOK, AND S. L. NIEUKIRK. **12-16 Oct. 2009**. Detecting bowhead whale (*Balaena mysticetus*) sounds in the Beaufort Sea: confounding sounds in a cacophony of noise. *Proc. 16th Biennial Conf. Biol. Mar. Mamm.*, pp.110-111. Québec, Canada.

KLINCK, H., N. CONSTANTINOU, D. K. MELLINGER, AND T. ROGERS. **2010**. Density estimation of leopard seals using a single stationary passive acoustic sensor. *J. Acoust. Soc. Am.* **127(3):** 1825(A).

KLINCK, H., D. K. MELLINGER, N. BOGUE, J. LUBY, B. JUMP, J. PYLE, G. SHILLING. **10-13 Sept. 2009**. An autonomous ocean glider using real-time acoustic detection and classification of marine mammal sounds. *Book of abstracts*, p.50, *Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics*. Pavia, Italy.

KLINCK, H., D. K. MELLINGER, N. M. BOGUE, J. C. LUBY, W. A. JUMP, J. M. PYLE, AND G. B. SHILLING. **2009**. Autonomous passive acoustic monitoring of marine mammals using the Seaglider: onboard real-time detection and classification of target signals. *Book of abstracts*, p86, *ONR Marine Mammal Program Review*. Alexandria, Virginia.

KLINCK, H., D. K. MELLINGER, K. KLINCK, N. M. BOGUE, J. C. LUBY, W. A. JUMP, J. M. PYLE, G. B. SHILLING, T. LITCHENDORF, AND A. S. WOOD. **2011**. Passive-acoustic monitoring of odontocetes using a Seaglider: First results of a field test in Hawaiian waters. *J. Acoust. Soc. Am.* **129(4):** 2536(A).

KÜSEL, E. T., H. KLINCK, AND D. K. MELLINGER. **22-26 Feb. 2010**. Sound propagation off the Oregon coast: a modeling approach to evaluate possible effects of man-made sound on the marine environment. *Abstract MT24A-03*, p.38. *Ocean Sciences Meeting*. Portland, Oregon.

KÜSEL, E. T., D. K. MELLINGER, L. THOMAS, T. MARQUES, D. MORETTI AND J. WARD. **July 2009**. Estimating beaked whale density from single hydrophones by means of propagation modeling. *Symposium: Estimating Cetacean Density from Passive Acoustics*, p3. La Jolla, California.

KÜSEL, E. T., D. K. MELLINGER, L. THOMAS, T. A. MARQUES, D. J. MORETTI, AND J. WARD. **10-13 Sept. 2009**. Density estimation of Blainville's beaked whales (*Mesoplodon densirostris*) from single hydrophones by means of propagation modeling. *Book of abstracts*, p.78, *Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics*. Pavia, Italy.

KÜSEL, E. T., D. K. MELLINGER, L. THOMAS, T. A. MARQUES, D. J. MORETTI, AND J. WARD. **7-10 Dec. 2009**. Estimating beaked whale density from single hydrophones by means of propagation modeling. *Book of abstracts*, p87, *ONR Marine Mammal Program Review*. Alexandria, Virginia.

KÜSEL, E. T., D. K. MELLINGER, L. THOMAS, T. A. MARQUES, D. J. MORETTI, AND J. WARD. **2010**. Estimating density from single hydrophones by means of propagation modeling. *J. Acoust. Soc. Am.* **127(3):** 1824(A).

LU, Y., H. KLINCK, AND D. K. MELLINGER. **2011**. Noise reduction for better detection of beaked whale clicks. *J. Acoust. Soc. Am.* **129(4):** 2536(A).

MARQUES, T. A., L. THOMAS, S. W. MARTIN, D. K. MELLINGER, S. JARVIS, N. DiMARZIO, AND R. P. MORRISSEY. **14-20 Sept. 2009**. Spatially explicit capture-recapture methods to estimate minke whale abundance from data collected at bottom mounted hydrophones. *Proc. EURING 2009*. Pescara, Italy.

MARTIN, S. W., T. A. MARQUES, L. THOMAS, D. MORETTI, R. MORRISSEY, N. DiMARZIO, S. JARVIS, AND D. K. MELLINGER. **July 2009**. Estimating minke whale boing density at Pacific Missile Range Facility, Hawaii. *Symposium: Estimating Cetacean Density from Passive Acoustics*, p.8. La Jolla, California.

MARTIN, S. W., T. NORRIS, E.-M. NOSAL, D. K. MELLINGER, R. P. MORRISSEY, AND S. JARVIS. **2011**. Automatic localization of individual Hawaiian minke whales from boing vocalizations. *J. Acoust. Soc. Am.* **129(4):** 2506(A).

MARTIN, S. W, L. THOMAS, T. A. MARQUES, R. P. MORRISSEY, S. JARVIS, N. DiMARZIO, D. K. MELLINGER. **2010**. Minke whale boing vocalization density estimation at the Pacific Missile Range Facility, Hawaii. *J. Acoust. Soc. Am.* **127(3):** 1824(A).

MATSUMOTO, H., C. D. JONES, D. K. MELLINGER, AND R. P. DZIAK. **7-10 Dec. 2009**. Acoustic float for marine mammal monitoring. *Book of abstracts*, pp.70-71. *ONR Marine Mammal Program Review*. Alexandria, Virginia.

MELLINGER, D. K. **7-10 Dec. 2009**. Automatic detection for long-term monitoring of marine organisms. *Book of abstracts*, pp54-55, *ONR Marine Mammal Program Review*. Alexandria, Virginia.

MELLINGER, D. K. **2010**. Detecting sequences of calls. *J. Acoust. Soc. Am.* **127(3):** 2005(A).

MELLINGER, D. K. **2010**. Hot topics in animal bioacoustics. **Invited presentation**. *J. Acoust. Soc. Am.* **128(4):** 2390(A).

MELLINGER, D. K. **2011**. Introduction to Animal Bioacoustics. **Invited presentation**. *J. Acoust. Soc. Am.* **129(4):** 2406(A).

MELLINGER, D. K. **2011**. Detecting killer whale whistles and squeals. **Invited presentation**. *J. Acoust. Soc. Am.* **129(4):** 2606(A).

MELLINGER, D. K., D. GILLESPIE, C. CLARK, A. THODE. **17-19 Nov. 2009**. Signal processing overview. *Presentation Abstracts*, pp.14-15, *Acoustic Monitoring and Mitigation Systems: Status and Applications for Use by Regulated Offshore Industries*. Sponsored by: Minerals Management Service. Boston, Massachusetts.

MELLINGER, D. K., H. KLINCK, N. M. BOGUE, J. C. LUBY, W. A. JUMP, J. M. PYLE, G. B. SHILLING, T. LITCHENDORF, A. S. WOOD. **22-26 Feb. 2010**. Ocean gliders for acoustic observation of marine mammals. **Invited presentation**. *Abstract BO44B-01*, p.93. *Ocean Sciences Meeting*. Portland, Oregon.

MELLINGER, D. K., E. KÜSEL, L. THOMAS, T. MARQUES. **2009**. Taming the Jez monster: Estimating fin whale spatial density using acoustic propagation modeling. *J. Acoust. Soc. Am.* **126(4):** 2229(A).

MELLINGER, D. K., E. T. KÜSEL, L. THOMAS, T. MARQUES, D. MORETTI, P. BAGGENSTOSS, J. WARD, N. DIMARZIO, AND R. MORRISSEY. **2010**. Population density of sperm whales in the Bahamas estimated using propagation modeling. *J. Acoust. Soc. Am.* **127(3):** 1824(A).

MELLINGER, D. K., S. W. MARTIN, J. YOSCO, R. P. MORRISSEY, N. A. DIMARZIO, D. J. MORETTI, L. THOMAS. **10-13 Sept. 2009**. An algorithm for detection of whistles, moans, and other tonal sounds. *Book of abstracts*, p.48, *Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics*. Pavia, Italy.

MELLINGER, D. K., S. L. NIEUKIRK, S. L. HEIMLICH, K. KLINCK, AND H. KLINCK. **2010**. Software for viewing and checking automatic detections. *J. Acoust. Soc. Am.* **128(4):** 2299(A).

MELLINGER, D. K., S. L. NIEUKIRK, K. KLINCK, H. KLINCK, R. P. DZIAK, M. FOWLER, P. J. CLAPHAM, AND B. BRANDSDÓTTIR. **12-16 Oct. 2009**. Right whales rediscovered off Greenland. *Proc. 16th Biennial Conf. Biol. Mar. Mamm.*, p.164. Québec, Canada.

MORRISSEY, R. P., N. A. DIMARZIO, D. J. MORETTI, S. W. MARTIN, D. K. MELLINGER, J. YOSCO, C. CIMINELLO, L. THOMAS. **10-13 Sept. 2009**. Passive acoustic detection of minke whales (*Balaenoptera acutorostrata*) off the West Coast of Kauai, HI. *Book of abstracts*, p.57, *Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics*. Pavia, Italy.

NIEUKIRK, S. L., S. L. HEIMLICH, S. E. MOORE, K. M. STAFFORD, R. P. DZIAK, M. FOWLER, J. HAXEL, J. GOSLIN, AND D. K. MELLINGER. **12-16 Oct. 2009**. Whales and airguns: An eight-year acoustic study in the central North Atlantic. *Proc. 16th Biennial Conf. Biol. Mar. Mamm.*, pp.181-182. Québec, Canada.

OLMSTEAD, T. J., M. A. ROCH, P. HURSKY, M. B. PORTER, H. KLINCK, D. K. MELLINGER, T. HELBLE, S. S. WIGGINS, G. L. D'SPAIN, AND J. A. HILDEBRAND. **2010**. Autonomous underwater glider based embedded real-time marine mammal detection and classification. *J. Acoust. Soc. Am.* **127(3):** 1971(A).

ROCH, M., Y. BARKLEY, S. BAUMANN-PICKERING, J. A. HILDEBRAND, P. HURSKY, H. KLINCK, D. K. MELLINGER, B. PATEL, M. PORTER, S. QUI, S. RANKIN, M. SOLDEVILLA, AND S. M. WIGGINS. **7-10 Dec. 2009**. Acoustic detections and how to manage them. *Book of abstracts*, pp.62-63, *ONR Marine Mammal Program Review*. Alexandria, Virginia.

ROCH, M., H. KLINCK, D. K. MELLINGER, M. S. SOLDEVILLA, AND J. A. HILDEBRAND. **12-16 Oct. 2009**. Flexible spatiotemporal databases for marine mammal observations. *Proc. 16th Biennial Conf. Biol. Mar. Mamm.*, p.217. Québec, Canada.

RUGH, D., C. ASHJIAN, M. BAUMGARTNER, C. BERCHOK, B. CAMPBELL, C. GEORGE, K. GOETZ, D. MELLINGER, J. MOCKLIN, S. OKKONEN, G. SHEFFIELD, M. SMULTEA, K. STAFFORD. **18-22 Jan. 2010**. The Bowhead Whale Feeding Ecology Study (BOWFEST). *Book of Abstracts*, p114, *Alaska Marine Sci. Symposium*. Anchorage, Alaska.

STAFFORD, K. M., C. L. BERCHOK, D. K. MELLINGER, AND S. E. MOORE. **18-22 Jan. 2010**. Ambient noise in Alaskan Beaufort Sea 2007-2009. *Book of Abstracts*, p115, *Alaska Marine Sci. Symposium*. Anchorage, Alaska.

THODE, A., AND D. K. MELLINGER. **2010**. History of proposed Acoustical Society standard on "Underwater Passive Acoustic Monitoring for Bioacoustic Applications." *J. Acoust. Soc. Am.* **128(4):** 2276(A).

THODE, A., AND D. K. MELLINGER. **2010**. History of the Acoustical Society of America's standard on "Underwater Passive Acoustic Monitoring for Bioacoustic Applications": Metadata issues. *J. Acoust. Soc. Am.* **128(4):** 2436(A).

YACK, T. M., J. BARLOW, M. A. ROCH, H. KLINCK, S. MARTIN, D. K. MELLINGER, AND D. GILLESPIE. **10-13 Sept. 2009**. Comparison of beaked whale detection algorithms. *Book of abstracts*, p.28, *Fourth International Workshop on Detection, Classification and Localization of Marine Mammals using Passive Acoustics*. Pavia, Italy.

Data exchanges

- Hundreds of data downloads from the MobySound.org web site (see above)
- Univ. Washington – beluga and bowhead whale recordings from the Beaufort Sea
- NOAA-NMML – recordings of many species from the Bering Sea
- Univ. New South Wales – Arnoux's beaked whale recordings from Antarctica
- JASCO Applied Sciences, Inc. – bowhead whale recordings from the Chukchi Sea
- Greenridge Sciences, Inc. – bowhead whale recordings from the eastern Beaufort Sea
- *M*amiferos, *E*ncuentros, *E*ducación, *R*econocimiento (MEER) – short-finned pilot whale recordings from the Canary Islands
- Alfred Wegener Institute – crabeater seal recordings from Antarctica
- Univ. Crete – sperm whales from the Mediterranean Sea

Dissertations/graduate theses
None.

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21.	Sue Moore NOAA at Applied Physics Laboratory University of Washington Seattle, WA	1

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	Norfolk, VA	
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	Naval Facilities Engineering Command, Atlantic	
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	National Marine Mammal Laboratory	
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50.	Laura J. Morse	1
	National Marine Mammal Laboratory	
	Seattle, WA	
51.	Anthony Martinez	1
	NOAA Southeast Fisheries Science Center	
	Miami, FL	
52.	Darlene R. Ketten	1
	Woods Hole Oceanographic Institution	
	Woods Hole, MA	
53.	David C. Mountain	1
	Boston University	
	Boston, MA	
54.	Melissa Soldevilla	1
	NOAA/NMFS	
	Southeast Fisheries Science Center	
	Miami, FL	

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61.	Ari Friedlaender Duke University Beaufort, NC	1
62.	CAPT Robin Fitch, USN (ret) Office Assistant Secretary of the Navy Energy, Installations, and Environment Washington, DC	1
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70.	Lisa K. Baldwin Scripps Institution of Oceanography University of California La Jolla, CA	1
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72.	Mariana L. Melcon Scripps Institution of Oceanography University of California La Jolla, CA	1
73.	Daniel L. Webster Cascadia Research Collective Olympia, WA	1
74.	Daniel J. McSweeney Wild Whale Research Foundation Holualoa, HI	1
75.	Sabre D. Mahaffy Cascadia Research Collective Olympia, WA	1

76.	Jessica M. Aschettino Cascadia Research Collective Olympia, WA	1
77.	Tori Cullins Wild Dolphin Foundation Waianae, HI	1
78.	Alison Stimpert Naval Postgraduate School Monterey, CA	1
79.	Diane Claridge Bahamas Marine Mammal Research Organisation Abaco, Bahamas	1
80.	Charlotte Dunn Bahamas Marine Mammal Research Organisation Abaco, Bahamas	1
81.	Cathy Bacon Smultea Environmental Sciences, LLC Issaquah, WA	1
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